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Evaporation Memo No 25

B G Wales-Smith

Lake and reservoir evaporation support study

(1) Changes in values of air temperature, vapour pressure and wind speed resulting from air movement from shore to lake.

(2) Studies of relationships between air and water surface temperatures and between water temperatures at various levels.

Source of data

The data used are those published in United States Geological Survey Professional Paper 270 "Water-Loss Investigations: Lake Hefner Studies, Base Data Report" (Washington 1954).

Site and location of observing positions

Fig 1 (a simplified version of the map inside the front cover of Geological Survey Circular 229: Washington 1952) shows the locations of observing points. The lake depth varies from a metre or so in shallows near parts of the shore to some 25 metres in deep areas. Lake Hefner is very approximately a square of 2 x 2 statute miles. Land and lake bottom contours and many other details (not shown in Fig 1) appear in the original map. A general description is given in G.S. Circular 229 by G Earl Harbeck Jr. The Circular also contains a set of scientific papers reporting studies of water and energy budgets, mass-transfer, lake and pan evaporation and the instrumentation.

Data processing

1. Wind direction at 2 metres at Barge (Station 1)

(a) 3 hour (coded) wind directions are tabulated in the Base Data Report; these were summarized, day by day, from July 1950 to June 1951. The code, using only the figures 2, 3 and 4, refers to the corresponding upwind meteorological station as a convenient index of direction. The barge station recorded a few occasions of wind from sector 4, but none at all from sectors 5, 6 and 1 which were allotted to directions from (approx) 340° through west (270°) to 205°. If only one or two 3-hour period(s) in a day differed in direction from the other 7 (or 6) the predominant direction, only, was recorded in the summary. If 3 or more 3-hour periods differed from the "majority direction" all direction code figures were recorded, in decreasing order of frequency. If the day was "shared" between two directions the = sign was used (eg 2=3).

(b) Next, two sheets were prepared showing days with winds entirely or predominantly from stations 2 and 3, respectively (subsequently referred to as "upwind stations").

(c) Daily average, 2 metre wind speeds at Station 1 were extracted for the whole 12 month period. Speeds at stations 2 and 3 were tabulated for days when either was the "upwind station" from station 1 (barge)

2. Air temperature

Daily average wet and dry bulb temperatures at 2m were tabulated for Station 1. Values at Stations 2 and 3 were tabulated for days when either was the "upwind station" from Station 1 (barge)

3. Vapour pressure

Vapour pressures were calculated from the data at (2) for days when data were available from Stations 1 and 2 or 1 and 3 and when one or other (of 2 and 3) was the "upwind station".

4. Water surface temperature

Average daily water surface temperature was tabulated for Station 1.

5. Below-surface water temperatures

(a) All soundings made from Thermal Survey Station 10 (close to Station 1) from May 1950 to Aug 1951 were summarized as follows. Date; time; water surface temperature at barge (Station 1) interpolated from 3-hour average values where necessary; average temperature of the first metre; average temperature of the 10th metre; average temperature of the lowest metre sounded; maximum depth sounded.

(b) Shallow soundings made from the barge were summarized as follows. Date; time; water surface temperature (as recorded or interpolated); average temperature of the first metre; average temperature of the 10th metre.

Data analysis

1. Change of air temperature on crossing the water

193 cases were examined; 130 with Station 2 as the upwind station and 63 with Station 3 upwind from the barge.

(a) Wind from Station 2 to (Barge) Station 1

Air temperature at 2 higher than water temperature at 1

Air temp at 1 lower than at 2	75 cases
" higher than "	2 cases
" same as "	1 case

Air temperature at 2 lower than water temperature at 1:

Air temp at 1 higher than at 2	35 cases
" lower than "	13* "
" same as "	1 case

* in 5 of these the water temp at 2 was lower than the air temp and it seems likely that the barge value was not representative of the whole track.

Air temperature at 2 same as water temperature at 1

Air temp at 1 same as at 2	2 cases
" 1 not same as 2	1* case

* could be explained by reference to water temp at 2.

(b) Wind from Station 3 to (Barge) Station 1

Air temperature at 3 higher than water temperature at 1

Air temp at 1 lower than at 3	9 cases

Air temperature at 3 lower than water temperature at 1

Air temp at 1 higher than at 3	46 cases
" lower than "	3* "
" same as "	3* "

* most could be explained by reference to water temp at 3.

Air temperature at 3 same as water temperature at 1

Air temp at 1 same as at 3	1 case
" not same as 3	1 case

Most changes were in accordance with expectation.

Changes of temperature were distributed as follows:-

Track: Station 2 to Station 1

Change =	0	0.1-0.5	0.6-1.0	1.1-1.5	1.6-2.0	2.1-2.5 °C
No of cases	5	53	42	20	7	3

Track: Station 3 to Station 1

Change	0	0.1-0.5	0.6-1.0	1.1-1.5	1.6-2.0 °C
No of cases	4	29	23	6	1

2. Increase of air speed in flow from land to water

Figures 2 and 3 show increases of speed on nearly all occasions. Unfortunately there were no cases of NW-SW flow to rest the relationship between lake centre and onshore speeds.

3. Water temperatures

Fig 4 shows that the water surface temperature, measured at the barge (Station 1) form a coherent series.

Fig 5 shows that (as expected) the relationship between air temperature at 2m and water surface temperature was not good.

Fig 6 shows that soundings at Thermal Survey Station 10 form a choherent series and that all profiles were isethermal from late September to late April.

Fig 7 shows that water surface and average top-metre water temperatures were generally well related.

Fig 8 shows that top-metre and 10th metre water temperatures were very well related except at high temperatures.

4. Vapour Pressure

Figures 9 and 10 show that vapour pressure almost always increased when the air crossed the water.

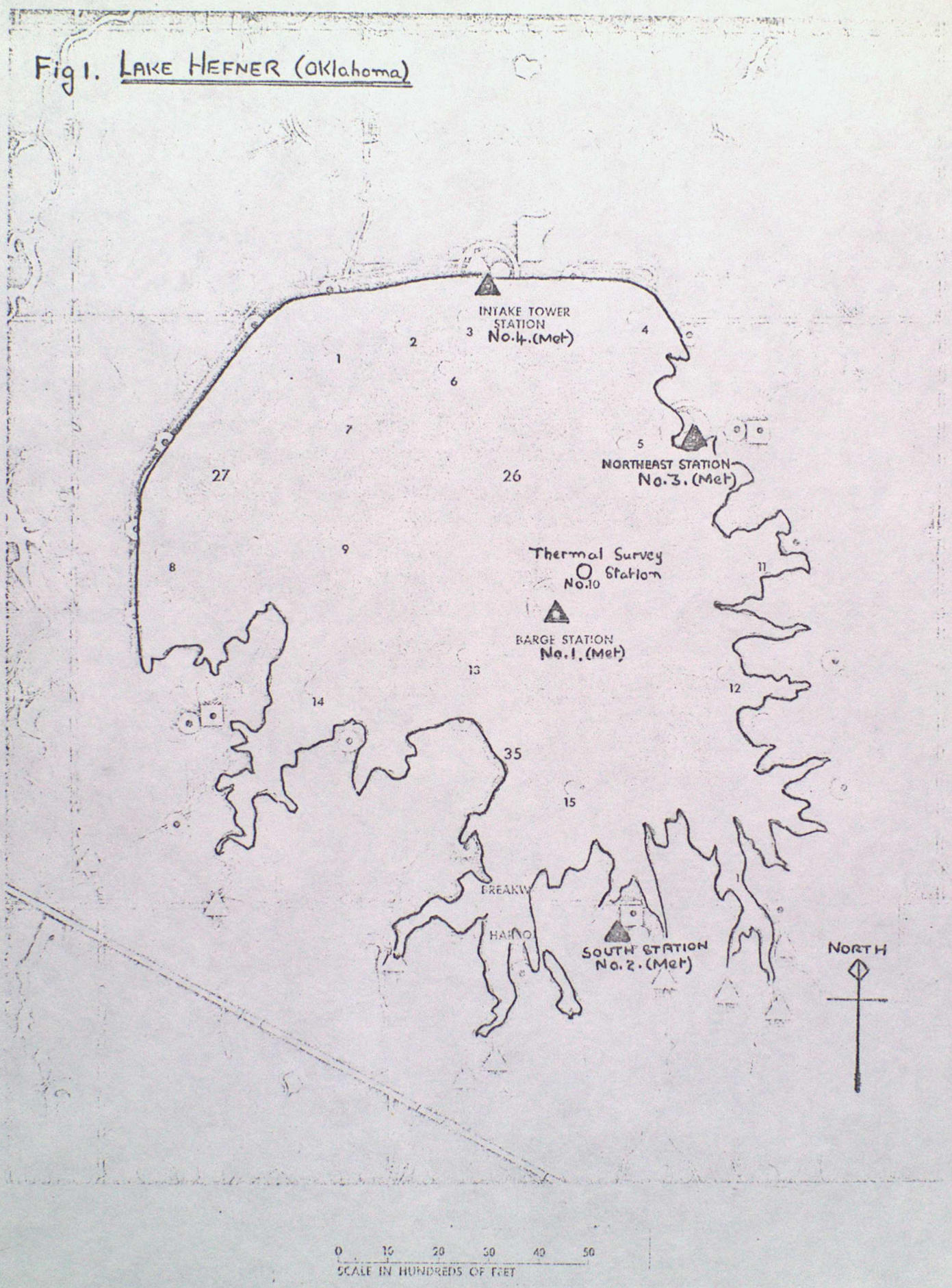
Conclusion and comments

Great efforts were made to achieve very high standards of instrumental accuracy and comparability between stations. This analysis accepts the data at their face value.

It appears that lake-representative values of wind speed at 2m, air temperature and vapour pressure (for the calculation of potential evaporation) should be measured near the centre of the lake. Water temperatures in the top metre were representative of the top ten metres except in the warm months when considerable differences occurred, presumably, in warm, sunny weather.

Bracknell
March 1973

Fig 1. LAKE HEFNER (Oklahoma)



DISTANCES (Approx)

STN. 2 to STN. 1. 1·2 MILES (1·9 KM)
STN. 3 to STN. 1. ·9 MILES (1·4 KM)

Fig. 2. Comparison of Average Daily 2m Wind Speeds on Days with Flow from Station 2 to (Barge) Station 1. Jul 1950 - Jun 1951

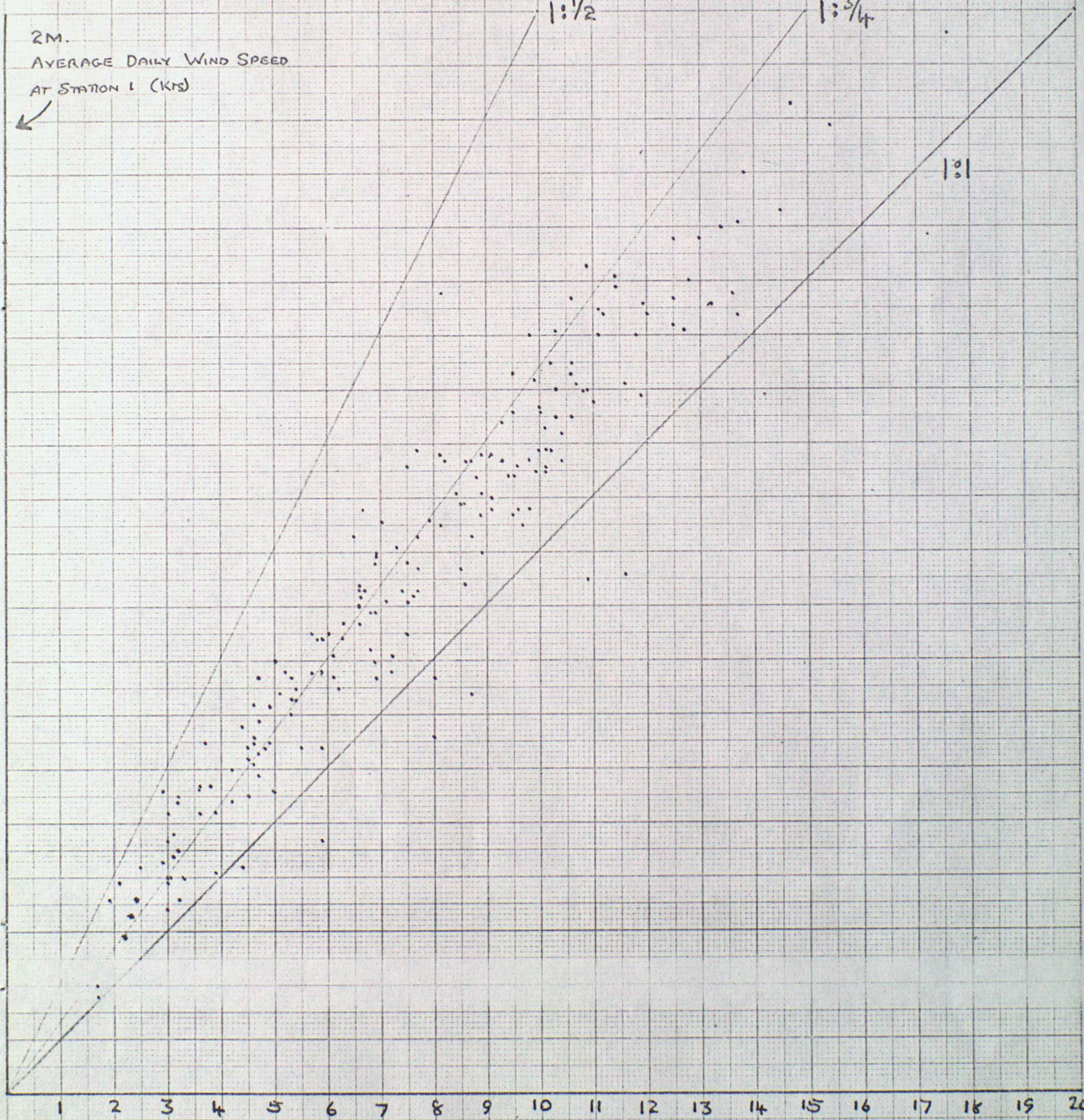

1:½
1:¾
1:1
2M.
Average Daily Wind Speed
at Station 1 (Kts)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
2M. Average Daily Wind Speed at Station 2 (Kts)

Fig 3. Comparison of Average Daily 2m Wind Speeds on days with flow from Station 3 to (Barge) Station 1 Jul 1950 - Jun 1951.

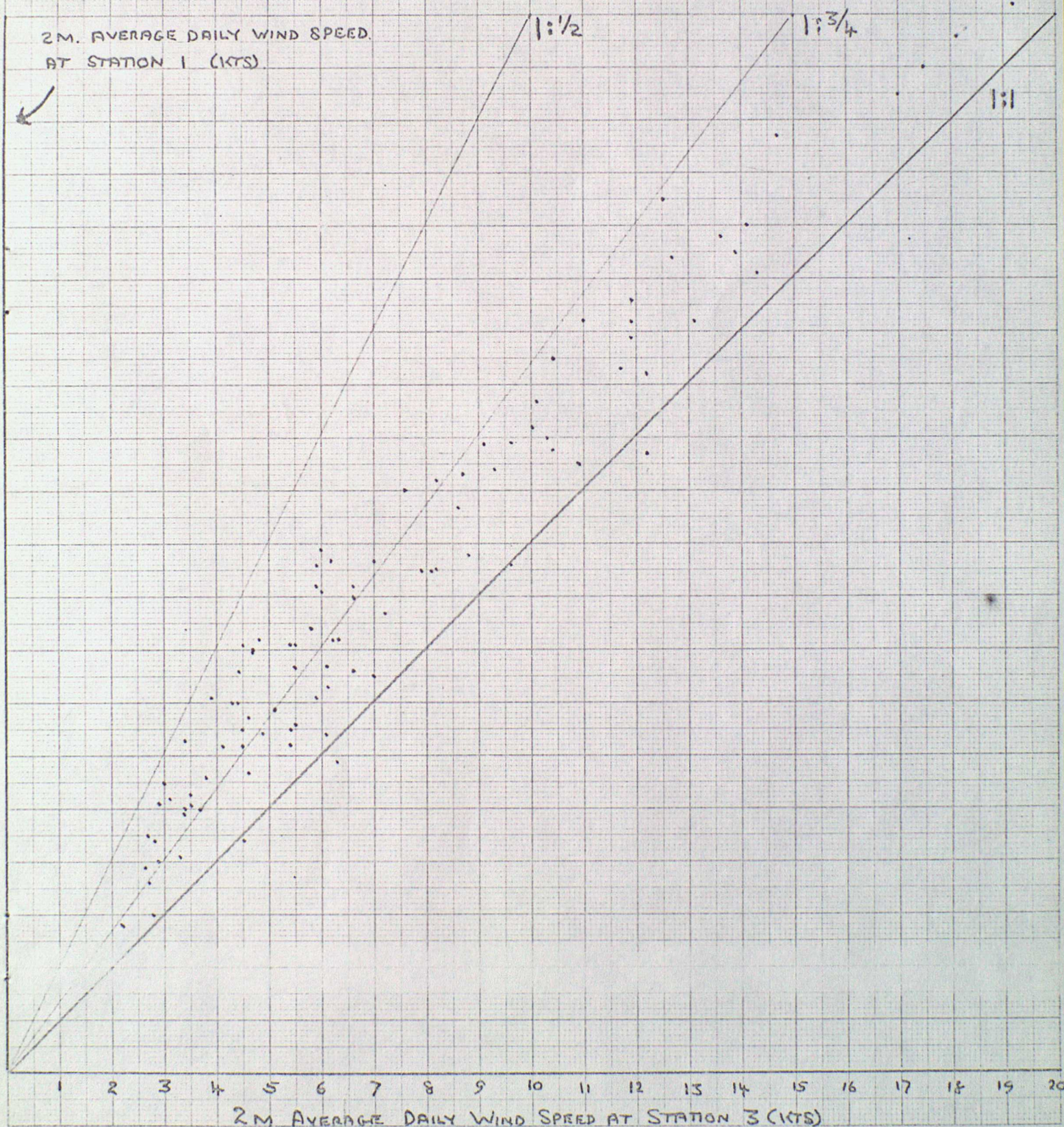
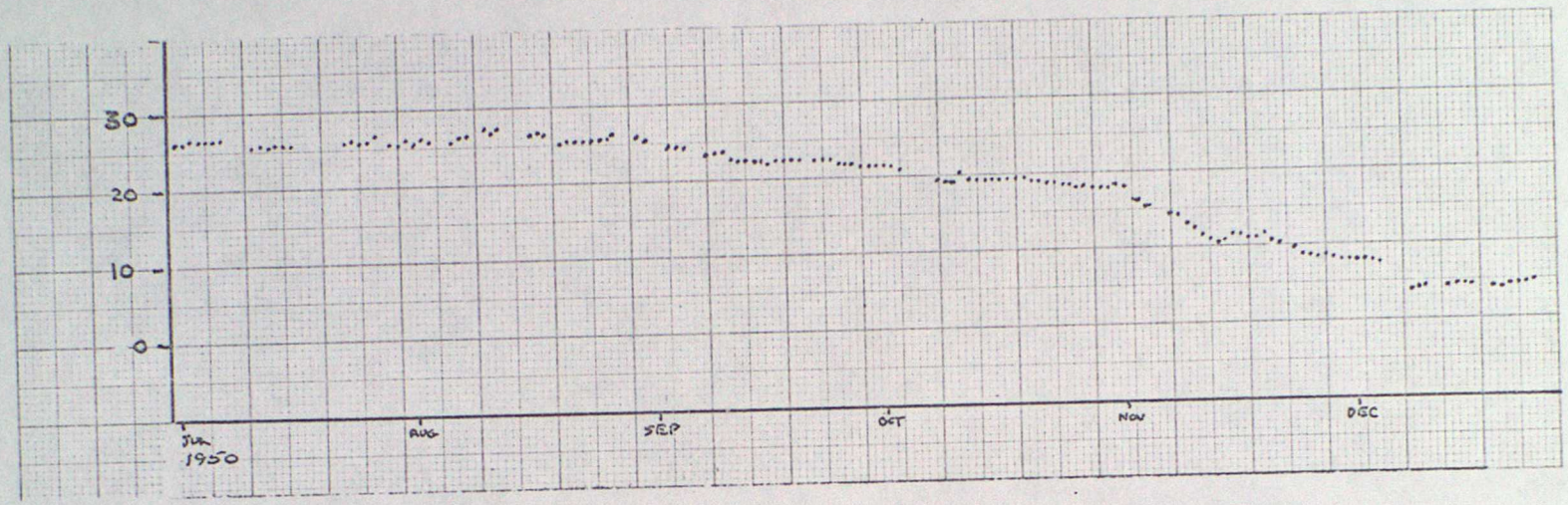


Fig 4. LAKE HEFNER DAILY AVERAGE WATER SURFACE TEMPERATURE - BARGE STATION (No.1.)
JULY 1950 - JUNE 1951.



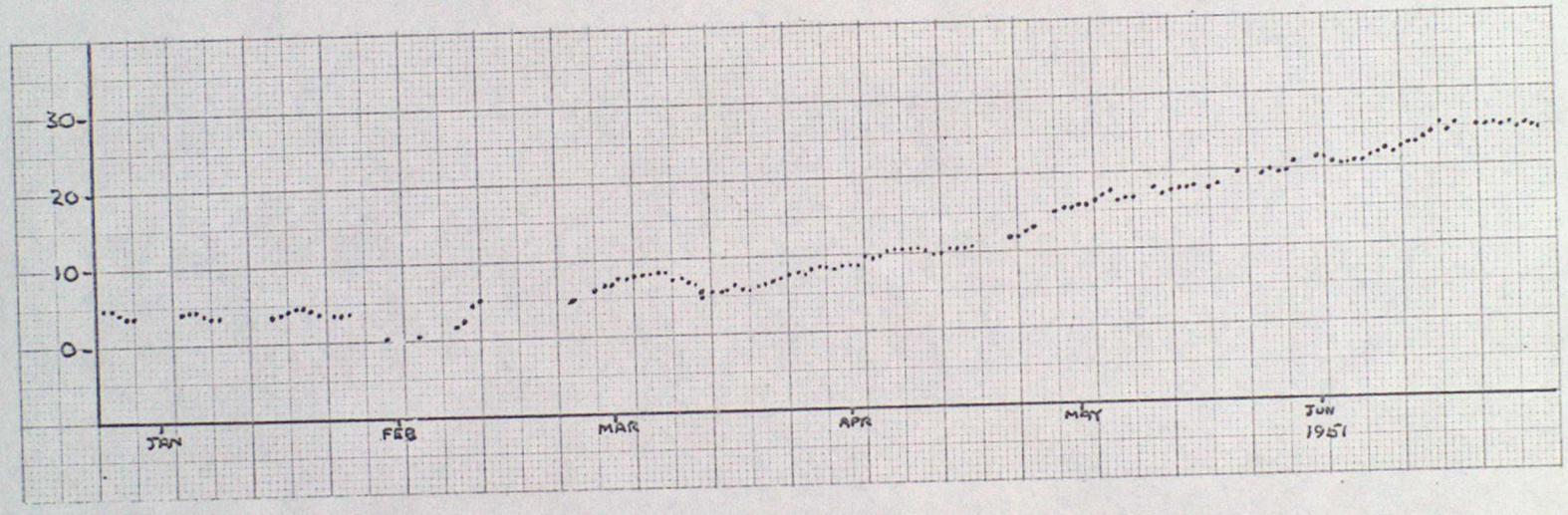


Fig 5.

LAKE HEFNER – BARGE STATION – NO. 1. JUL 1950–JUN 1951

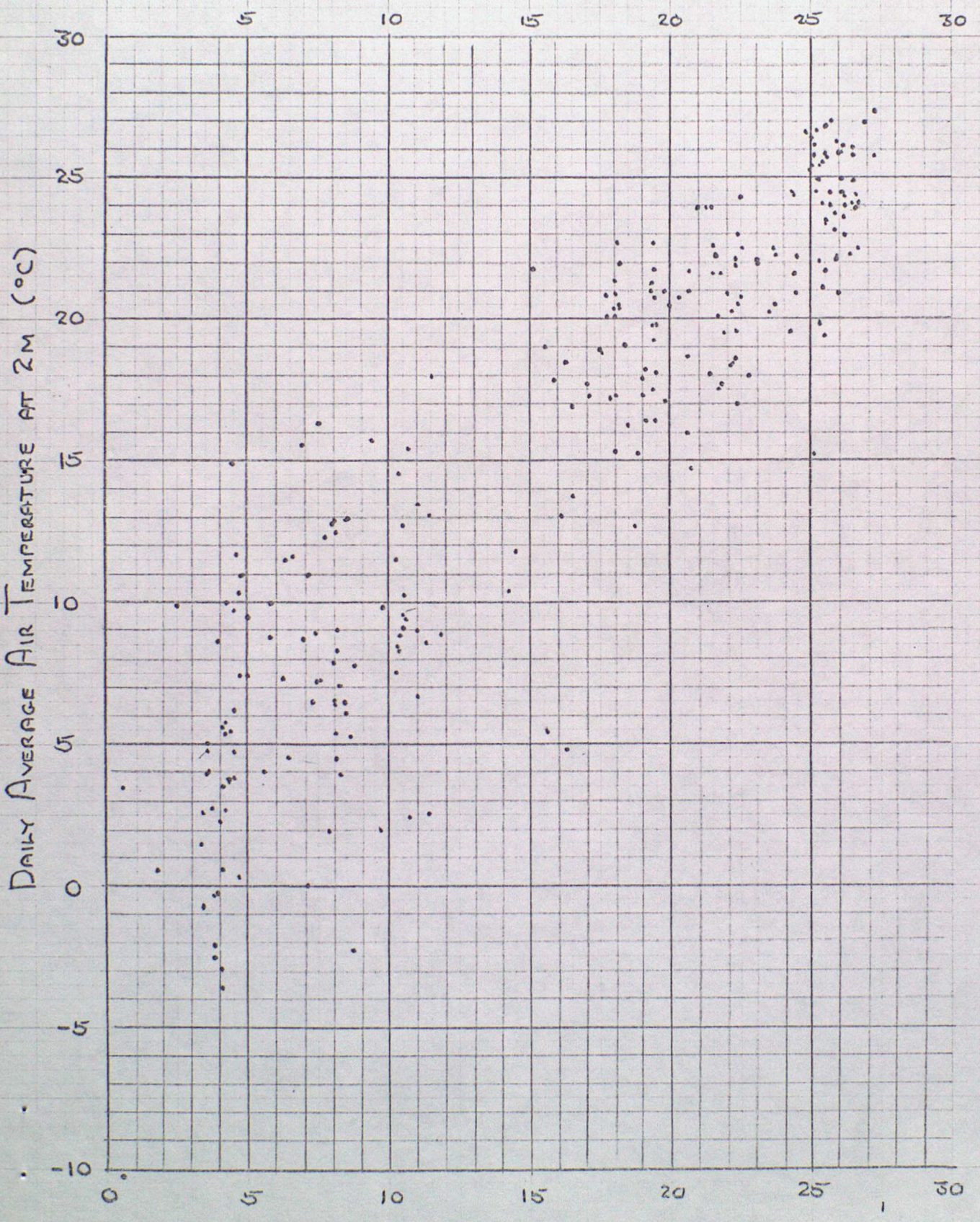


Fig. 6. WATER TEMPERATURES IN { FIRST METRE ⊙ / TENTH METRE × / LOWEST METRE SOUNDED •

UPPER FIGURE = TIME OF SOUNDING (HRS).
LOWER FIGURE = LOWEST SOUNDING (M)

THERMAL SURVEY STN 10.

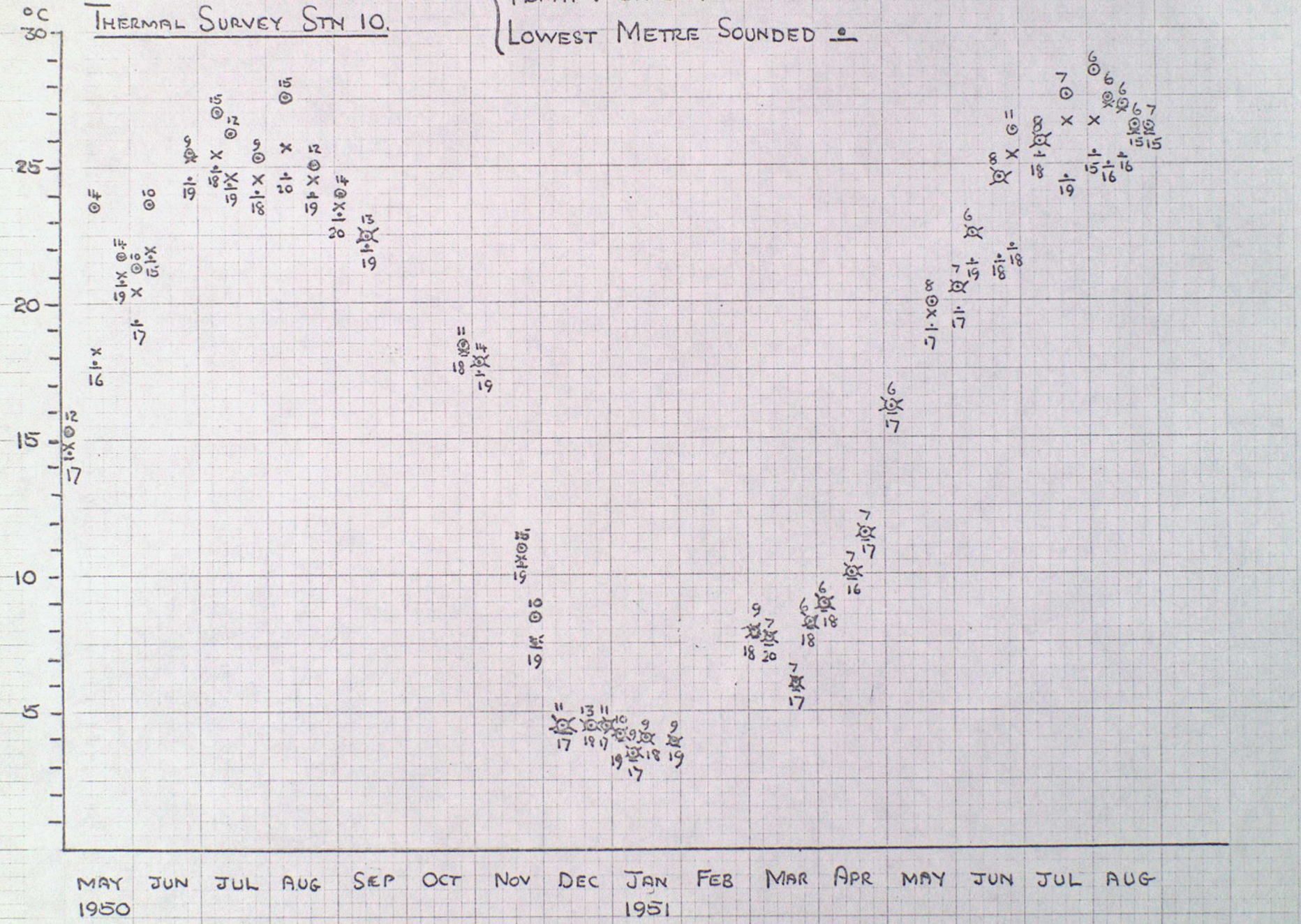


Fig. 7.

COMPARISON OF WATER SURFACE TEMPERATURE AND AVERAGE TEMPERATURE IN THE TOP METRE.
(67 SOUNDINGS)

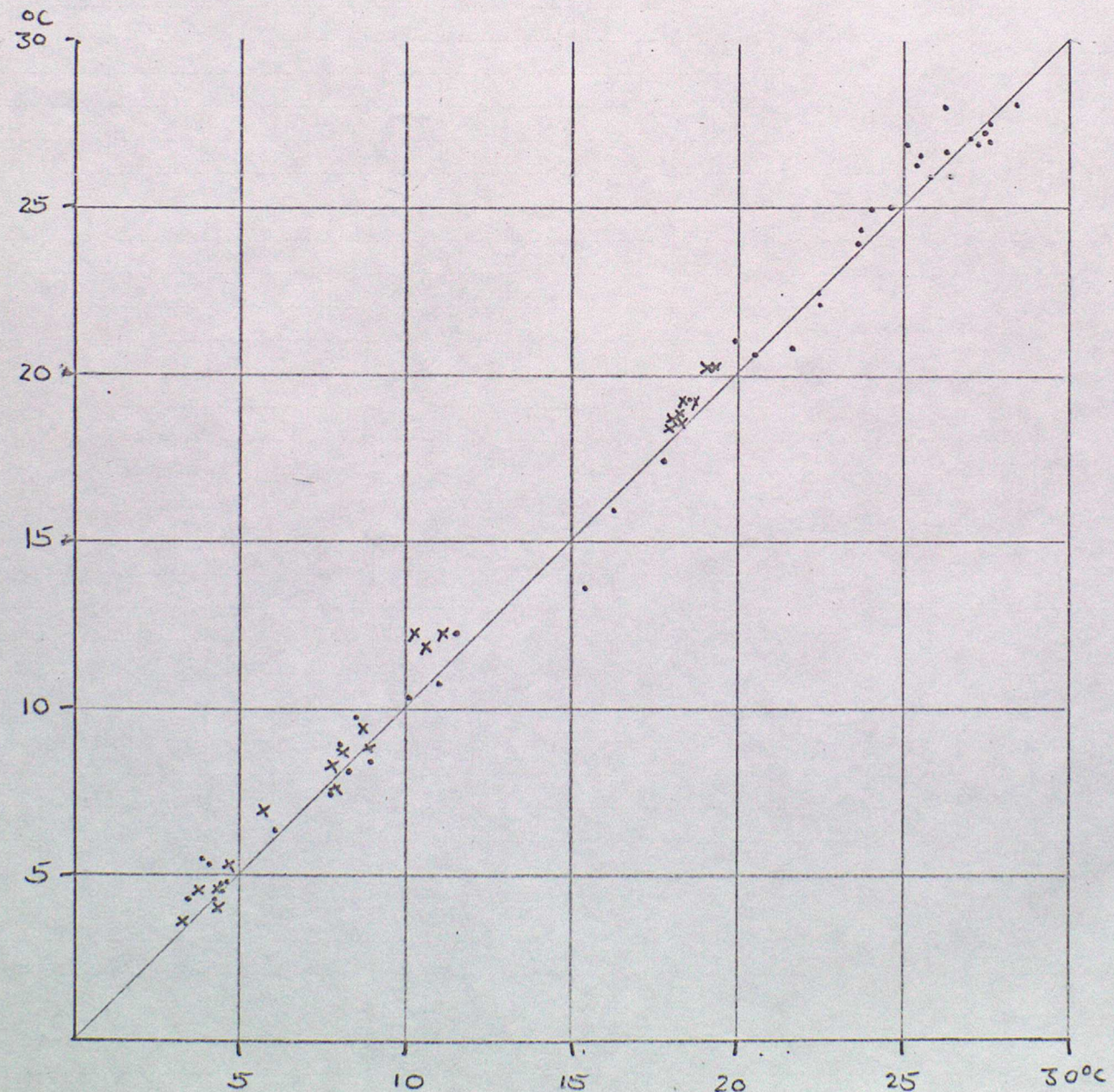


Fig. 8.

COMPARISON OF AVERAGE WATER TEMPERATURES IN THE FIRST AND TENTH METRES (67 SOUNDINGS)

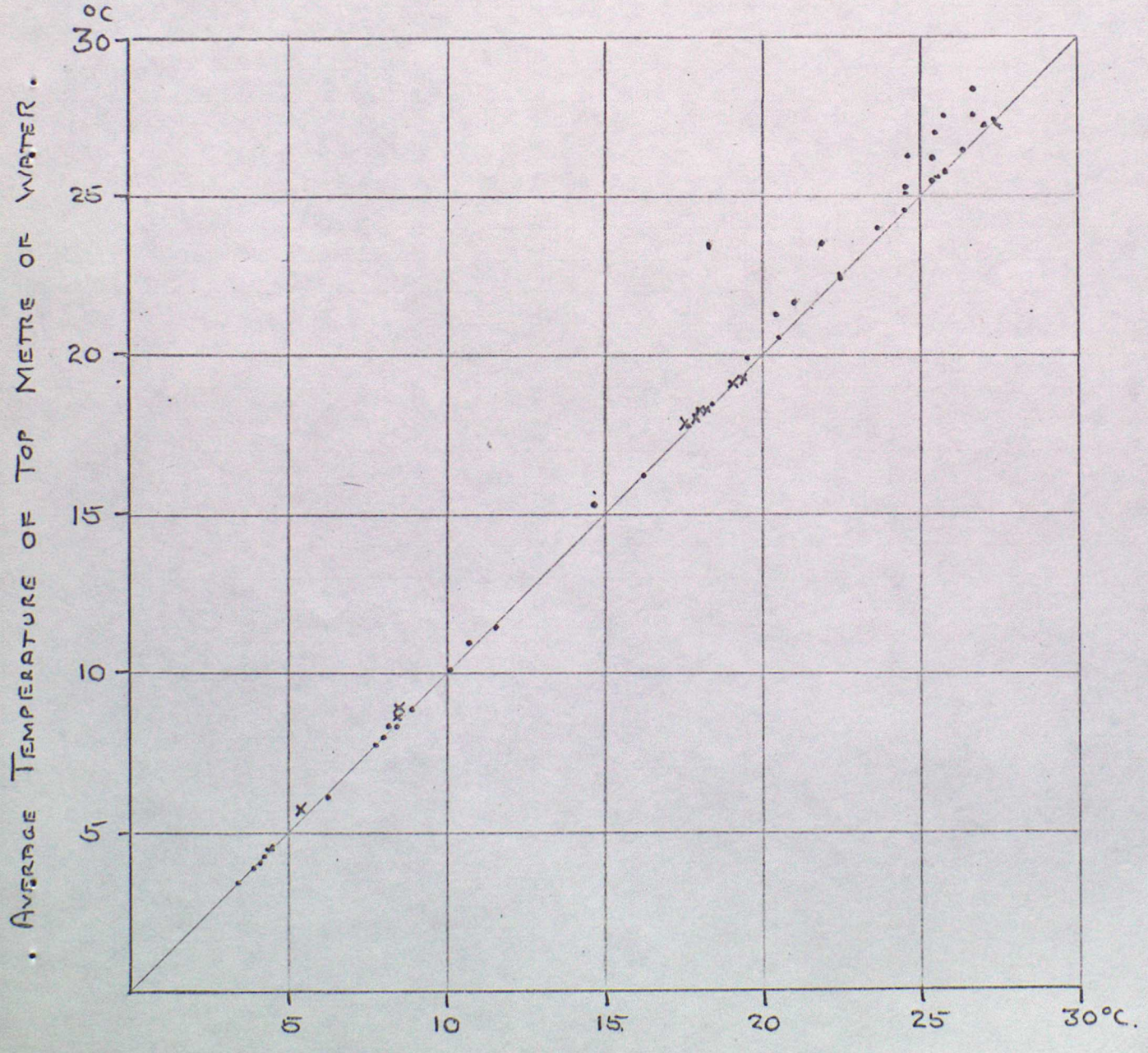


Fig. 9.

COMPARISON OF DAILY AVERAGE VAPOUR PRESSURE AT 2M ON DAYS WITH 2M WIND BLOWING FROM STATION 2 TO (BARGE) STATION 1 . JULY 1950 – JUN 1951.

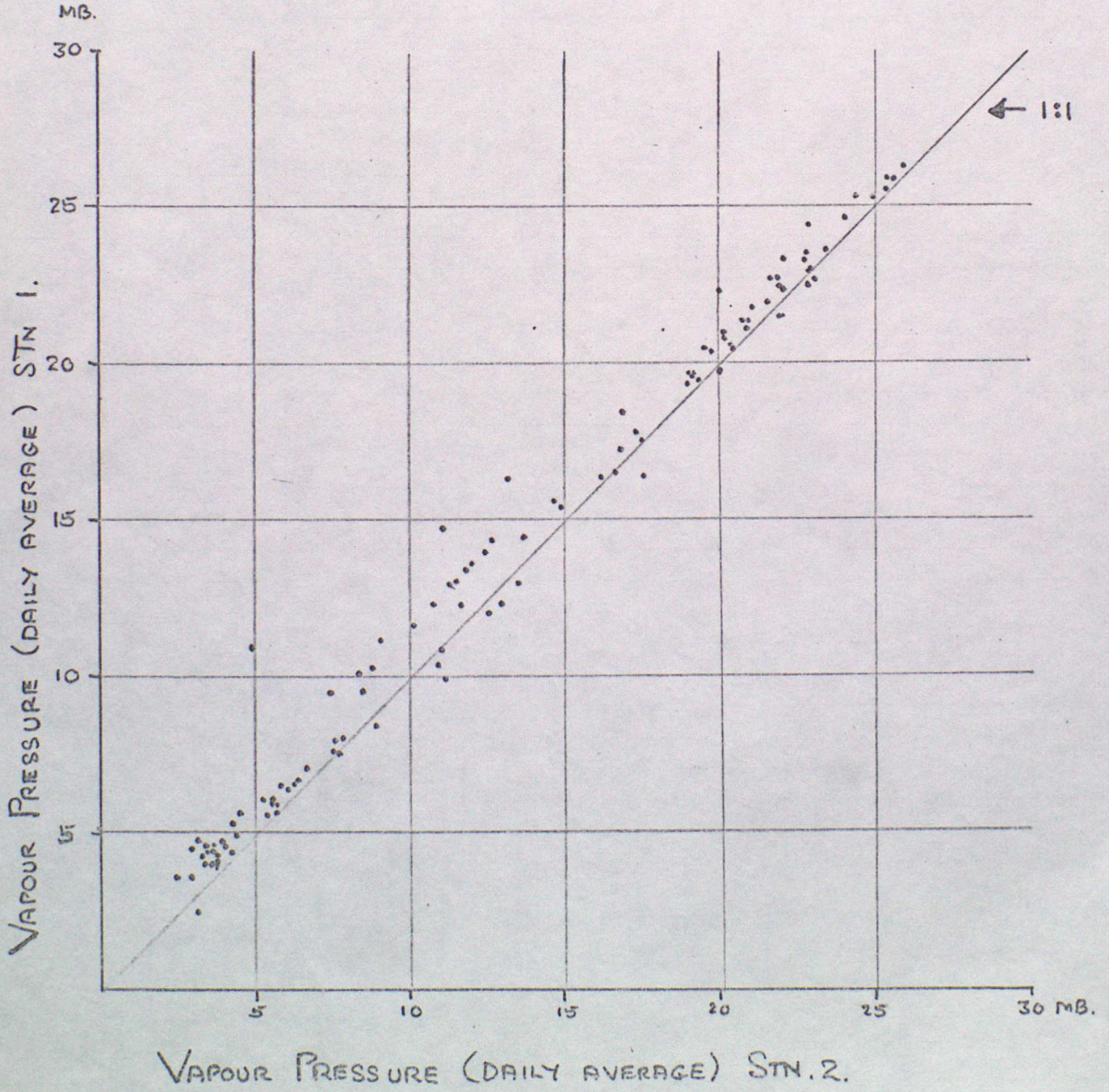


Fig. 10.

COMPARISON OF DAILY AVERAGE VAPOUR PRESSURE AT 2M. ON DAYS WITH 2M WIND BLOWING FROM STATION 3 TO (BARGE) STATION 1. JUL 1950 – JUN 1951.